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Dytiscidae, Noteridae and Hydrophilidae of semi-arid rivers and reservoirs of Burkina Faso: species inventory, diversity and ecological notes

I. Kaboré[1,3*], M.A. Jäch[2], A. Ouéda[3], O. Moog[1], W. Guenda [3], A.H. Melcher[1]

[1] *Institute of Hydrobiology and Aquatic Ecosystem Management, Department of Water, Atmosphere and Environment, University of BOKU, Vienna, Austria*

[2] *Natural History Museum of Vienna, Austria*

[3] *Laboratory of Biology and Ecology Animals (LBEA), University of Ouagadougou, Burkina Faso*

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Abstract

Conservation of biodiversity is a major concern due to climate change and pressure from human activities. Knowledge of aquatic insects and their ecology particularly in West Africa is still scanty and fragmented. To fill this gap, we investigated the structure of aquatic beetle assemblages from 18 lentic and lotic water bodies (rivers and reservoirs) in Burkina Faso, and we explored their relationship with environmental variables. Following a multi-habitat sampling approach, all beetles were collected with a hand net, and identified using taxonomic manuals and keys. A total of 11 species of Noteridae in three genera, 27 species of Dytiscidae in 10 genera and 22 species of Hydrophilidae in nine genera were identified in this study. Among these, 24 species are here reported for the first time from Burkina Faso. The species richness was high in the reservoirs with habitats dominated by "water lettuce" *Pistia stratiotes* (species diversity, sd=11.0±9.00 Shannon Wiener index, H=1.79±1.1) and "reed beds" (species diversity, sd=7.63±1.78; Shannon Wiener index, H=1.51±0.25) in comparison with rivers (sd=2.25±0.75; H=0.35±0.20). The results also showed that the species richness is significantly correlated with vegetation cover. Thus, emergend water plants were found to be the main factor influencing beetles species richness. The observed relationship between vegetation cover and beetle richness may provide significant insights that motivate future efforts in research as well as in habitat conservation measures in West Africa.

***Corresponding Author:** Kaboré ✉ ikabore16@yahoo.fr

Introduction

Freshwater Beetles constitute the second largest aquatic insect order with about 13,500 species world-wide (Balian *et al*., 2008; Jäch and Balke, 2008). The Afrotropical Region harbours about 2,700 (Jäch and Balke, 2008). There are, however, major information gaps concerning the knowledge of the invertebrate fauna of West Africa. Several recent surveys carried out in Sierra Leone and Côte d'Ivoire have led to the discovery of many new species, especially in the order of Coleoptera (Franciscolo, 1982, 1994; Castellini, 1990; Reintjes, 2004). Aquatic beetles are abundant in many types of aquatic habitats, which are most sensitive to human alterations (García-Criado *et al*., 1999). Therefore, aquatic beetles are used as bioindicators of water quality and global climate changes as an outcome of human activities (acidification, climate warming, etc.) and serve as "early warning" organisms detecting possible disturbances and changes in ecosystems (Valladares *et al*., 1994; Collinson *et al*., 1995; Moreno *et al*., 1997; Shepherd and Chapman, 1998; Sánchez *et al*., 2006; Guareschi *et al*., 2012). However, rapid population growth, constant desertification and climate change have raised a major concern over the management and conservation of the biological integrity in tropical areas. Thus, the Coleoptera became suitable for assessing the conservation status of the sites (Ribera, 2000; Abellán *et al*., 2005; Segura *et al*., 2007). However, ecological studies on Afrotropical beetles are scarce (Reintjes, 2004). As a consequence, our knowledge on the ecology of this group of insects in semi-arid areas is extremely poor, despite the current research initiatives. Among West African countries Côte d'Ivoire has received considerable attention from taxonomists working on Noteridae and Dysticidae (Reintjes, 2004). In Burkina Faso only few studies on aquatic insects have focused on beetles (Guenda, 1996; Kaboré *et al*., 2016). Our study revealed numerous new species records for Burkina Faso. Qualitative data on beetles were collected in several parts of the country, covering different types of waterbodies. Consequently the key aims of this work were 1) to identify and determine the diversity of Dytiscidae, Noteridae and Hydrophilida*e* in the sampling area and 2) to test and discuss their response to environmental variables.

Material and method

Study area

Burkina Faso is located in the heart of West Africa in the Sub-Saharan region (12° 16′ N, 2° 4′W; Fig. 2). The climate is tropical semi-arid with maximal temperatures varying between 24 and 40°C (Ly *et al*., 2013). Evapotranspiration is between 1,700 to 2,400 mm per year exceeding annual precipitation which ranges from 400 to 1,200 mm (MECV, 2007). The study was undertaken in two local river catchments: the Nakanbé, White Volta catchment (size 70,000 km²), in the central part of Burkina Faso and the Mouhoun, Black Volta catchment (92,000 km²), in the western part of the country. A total of six investigation areas (i.e. Koubri, Nazinga Game Ranch, Bagré, Boura, Sourou and Ouagadougou) termed by Koblinger and Trauner (2013) were chosen, and 18 investigation sites composed of different habitats were sampled (Tab. 1). These habitats were mainly dominated by the following plants species (Fig.1a-d): water lilies "*Nymphea* sp.", Reeds "Typha", water lettuce "*Pistia stratiotes*" and water hyacinth "*Eichhornia crassipes*".

The area of Koubri was described by Melcher *et al.* (2012) and Koblinger and Trauner (2013) and is located 40 km southeast of Ouagadougou along highway N5. It is located between the latitudes 12° 07' 35.88N & 12° 07' 05.15''N and the longitudes 01° 16' 57.37''W & 01° 26' 08.72''W (WGS84; Google Earth). The sampled reservoirs, Napagbtenga, Poedgo Segda and Noungou, were constructed between 1962 and 1988; their sizes range from five to 430 ha (Ouédraogo, 2010; Melcher *et al*., 2012).

The Game Ranch of Nazinga is a protected area located in the south of Burkina Faso, 60 km south of the city Ouagadougou close to the border to Ghana. The area is located between the latitudes 11° 03' 04''N & 11° 12' 47''N and the longitudes 01° 23' 25''W & 01°

43’00’’W. Eleven (11) reservoirs (18 to 60 ha of large) were created between 1981 and 1987 to improve water supply for wild animals during dry seasons. Among these waterbodies, two reservoirs (Talanga, Kozougou) and one free flowing section (Bodjéro) were sampled (Fig. 1a & 1c).

The Bagré hydro-agricultural dam is located on the Nakanbé River in a large valley about 150 km south-east from Ouagadougou (Villanueva *et al.*, 2006). The large reservoir was created in 1994. The total size and volume have a seasonal fluctuation between 100 and 196 km^2 and repectively between 0.88 and 1.7 billions m^3, whereas the maximum flow rate at the dam is up to 1,500 m^3/s (Villanueva *et al.*, 2006).

The Boura reservoir (11° 02’ N, 2° 30’ W) described by Sanogo *et al.* (2014) was built in a tributary of Mouhoun River to supply water and an integrated irrigation system for the local population. There are about 40,000 inhabitants in 22 villages close to the dam. Aquatic plants in the reservoir are dominated by “Reeds” (Fig. 1b). This water body was built in 1983 by the National Office of Dams and Irrigation (ONBI) and has a maximum capacity of 4.2 million m^3.

The Sourou valley described by Dianou *et al.* (2011) and Rosillon *et al.* (2012) is located in the north-west of Burkina Faso. The Sourou River takes its source in Mali. The Sourou valley is especially known for its hydro agricultural installations following the erection of dam valves at the junction of Sourou and Mouhoun rivers in 1984. The construction of the dam increased significantly the stock of water in the Sourou River (600 million m^2) through the valley. This availability of water prompted the creation of irrigation systems, hence the importance of the Sourou valley in agricultural production. Three sampling sites (Nianssan 1 and 2, Gouran) have been selected in this area.

The area of Ouagadougou (12° 21′ 26’’N, 1° 32′ 7’’W), the capital of Burkina Faso, including the sampling sites of Kougri, Bissiga and Korsimoro. This area is characterizd by the tropical climate with average monthly temperatures ranging from 24.5 to 28.8°C. Locally, the mean annual precipitation in Ouagadougou is 740 mm and shows an average of 66 rainy days between April and October (INSD, 2006a). All Bissiga, Korsimoro and Kougri sites are characterized by sediment bed (e.g. mud, sand, fine gravel), whereas the site in Ouagadougou, Reservoir number two, with an area of 226 ha is impacted by *Echhornia* (Fig. 1d).

Beetle sampling and identification

All beetles were sampled with a hand net (rectangular opening: 25 cm x 25 cm, mesh size: 500 µm), following the multi-habitat sampling approach by (Moog 2007). A pooled sample, consisting of 20 sampling units, was taken from each habitat or mixed samples on each sampling site. Samples were fixed in 90% ethanol, sieved in the laboratory and the animals have been sorted using a microscope. All taxa have been identified to the lowest taxonomic level as possible. The organisms were identified based on taxonomic manuals and keys by Tachet *et al.* (2003) and Lévêque and Durand (1981). Additionally direct taxonomic expert support was given by experts from the Natural History Museum Vienna following the most recent revisions. A total collection of all species cited here is deposited and stored in the Natural History Museum Vienna, Austria.

Analysis of environmental variables

In order to assess the diversity for Burkina Faso aquatic beetles, environmental parameters were collected in 2012 over four months in each of the 18 study sites (Tab. 1). The physico-chemical variables include water temperature (°C), conductivity (µS/cm), dissolved oxygen (mg/l) and pH and have been measured *in situ* with field multimeters (WTW340I) between eight am and three pm. The dominating habitat have been qualitatively estimated in each site (Fig. 1a-d).

Data analysis

A grouping (typology) of sampling sites in respect to their environmental descriptors was undertaken by

using Ward method cluster analysis (euclidian distance). All variables were z-standardized prior to the analysis. The relationship between beetles richness and environmental variables was explored using Spearman rank correlation. The total species richness was taken as the frequency of the number of taxa present in each investigation site. The Shannon Wiener (H') diversity index was expressed following the formulae below,

$$H' = -\sum_{i=1}^{s} p_i \ln p_i \quad [1]$$

where p_i is the proportion of individuals found in the ith taxon, S is the number of species in samples. All statistical analyses have been performed with IBM SPSS (version 21).

Results

In general most of the study sites had warm water temperatures (mean 30.5 °C), a neutral pH (mean of 7.55), low conductivity (mean 100 µS/cm) and sufficient oxygen contents (Tab. 2). The sampling sites in Ouagadougou receive domestic and industrial wastes. Consequently, high conductivity (406 µS/cm) and low disolved oxygen (1.65 mg/l) were measured in this area.

Table 1. Summury of the sampling sites charasteristics. Abreviation: W_Tem= water temperature, Cond= conductivity, DO= dissolved oxygen, R= reed, S= sediment, E= *Eichhornia*, N= *Nymphea*, P= *Pistia*.

Sites names	Codes	Sampling areas	Latitude (WGS84)	Longitude (N)	Altitude (m)	W_Temp (°C)	pH	Cond (µS/cm)	DO (mg/l)	Water types	habitat covers	Sampling periods
Napagbtenga	R1	Koubri	12.22111	-1.34901	281	33.5	7.01	50.2	6.2	Reservoir	R	October
Poedgo	R2	Koubri	12.18033	-1.34221	279	32	7	49.8	7.3	Reservoir	R	October
Boura	R3	Boura	11.04914	-2.49964	274	32.7	6.75	52	4.1	Reservoir	R	August
Segda	R4	Koubri	12.22352	-1.28419	276	32	7.17	86.5	4.8	Broken reservoir	R	October
Gouran	R5	Sourou	13.08113	-3.42472	257	34	5.7	98.3	5.7	Irrigation channel	R	October
Beguédo	R6	Bagré	11.774	-0.74651	236	28.8	8	53.5	6.2	Reservoir	R	November
Wedbila	R7	Koubri	12.14926	-1.41818	287	7.95	7.95	58.4	7.4	Reservoir	R	October
Nianssan2	R8	Sourou	12.75463	-3.43418	253	35.4	8.3	127	4.5	Irrigation channel	R	October
Korsimoro	S1	Ouaga	12.82348	-1.04957	282	28.4	7.8	91	4.2	Irrigation channel	S	October
Kougri	S2	Ouaga	12.37811	-1.08075	258	35	7.2	55.6	3.9	River	S	October
Bissiga	S3	Ouaga	12.75083	-1.15056	273	35	7.2	55.6	3.9	River	S	October
Bodjéro	S4	Nazinga	11.09143	-1.50459	269	24.4	8.6	67.8	6.6	River	S	December
Kozougou	P1	Nazinga	11.1543	-1.531	273	25.3	8.5	81.2	3.7	Reservoir	P	December
Naguio	P2	Nazinga	11.12763	-1.5834	275	24.4	8.6	67.8	6.6	Reservoir	P	December
Nianssan1	N1	Sourou	13.11078	-3.44917	253	32.6	7.9	196.5	2.4	Irrigation channel	NR	October
Noungou	N2	Koubri	12.20314	-1.30492	278	30.3	7.4	45.1	6.7	Reservoir	NP	October
Talanga	N3	Nazinga	11.18935	-1.52651	275	27.6	7.45	83.6	6.8	Reservoir	N	December
Ouaga	U	Ouaga	12.3909	-1.524	290	27.4	7.2	406	1.65	Reservoir	E	October

Beetles species richness and families in Burkina Faso

A high diversity of water beetles with at total of 60 species was identified in this study. Most of them (27 species) belonged to the family Dytiscidae, followed by Hydrophilidae family (22 species) and 11 species of Noteridae were also recorded. Interestingly 24 species (40% of total species) were recorded for the first time for Burkina Faso (Tab. 3). The most frequently occurring species *Helochares* (*Hydrobaticus*) sp. (55%) and *Hydrovatus aristidis* (28%) belong to

Hydrophilidae and Dytiscidae families, respectively.

Beetles structure in different waterbodies types

The Cluster analysis shows a clear discrimination of investigation sites into five main habitat types (C1 to C5) and their attached cluster groups, which are based on physico-chemical parameters and habitats (Fig. 3). Cluster C1 (R1-R8) indicate semi-aquatic vegetation sites "Reed beds" with water temperature values above 31 °C. In contrast C2 (S1-S4) are characterized by a high sediment load. C3 (P1-P2) reservoirs covered by aquatic plant "*Pistia*" and having a rather high pH of about 8.55. Finally C4 (N1-N3) is composed of mixed habitat with "*Nymphea*", and C5 (E) represents the single reservoir of *Eichhornia* habitat found in the Ouagadougou.

Table 2. Summary statistics of physico-chemical measured in field for the 18 sampling sites. Abbreviation: Max= Maximum, Min= Minimum. Parenthesis indicate the standar deviation.

Physico-chemical descriptors	All sites (n=18)		
	Mean	Min	Max
Temperature	30.43 (±3.52)	24.4	35.4
Conductivity (µS/cm)	97.72 (±85.01)	45.1	406
Disolved Oxygen (mg/l)	5.19 (±1.68)	1.65	7.4
pH	7.55 (±0.73)	6	9

In relation to the identified clusters (groups), some differences related to habitats were observed in the beetle species diversity (Fig. 4). Thus, the species richness per site was high in the reversoirs (C1) coverved by "Reed beds" (mean species diversity, sd=7.63±1.78; mean Shannon Wiener index, H'=1.55±0.26), and in (C3) covered by *Pistia* (P) (sd=11.00±9.00; H'=1.79±1.10), while rivers with a high sediment load (C2) were dominated by mud, sand, fine gravel (sd=1.75±0.48; H=0.35±0.20) show low species diversity.

Relationship between beetles richness and environmental variables

Analyses between beetles communities and their corresponding environmental parameters (Tab. 4) indicated that conductivity was positively correlated with the *Eichhornia* cover (spearman correlation r=0.43, p> 0.05) , and the Hydrophilidae richness (r=0.37, p> 0.05), and negatively correlated with disolved oxygen (r=0.63, p<0.05). The water temperature showed negative correlation with *Pistia* cover (r=0.59, p<0.05). The significant possitive correlations were detected between the pH and *Pistia* cover (r=0.59, p<0.05). The "Reeds" cover were significantly correlated to Noteridae richness (r=0.74, p<0.05, positive); while the buttom sediment (e.g. mud, sand, fine gravel) and *Nymphea* cover is negatively correlated to the beetles richness in general.

Discussion

The total number of beetles species (60) collected in this study is higher than the only earlier study conducted by Guenda (1985) who reported 22 species. The big difference can be explained by the diverse types of habitats sampled; nevertheless the species richness of Noteridae (11) and Dytiscidae (27) found in this project is lower compared to those reported from other West African river catchments. Reintjes (2004) and Vondel (2005) reported 95 species of Dytiscidae and 120 species of Noteridae in other Western Africa subregion. The lower number of our species could be due to the fact that: (1) the vast majority of our samples were taken in one river basin, particulary in the central part of Burkina Faso. Extending the sampling to more habitats covering the entire climate gradient from north to south may increase the number of species in these groups; (2) our study covers only four months (i.e. December, October, November and August). Species may be missed, if they are not prevalent in the study area within this period.

Table 3. List of aquatic main family beetles and species recorded in Burkina Faso waterbodies. (*) first time recorded species in Burkina Faso. R= Reeds, S= sediment, E= Eichhornia, N= Nymphea, P= Pistia.

Families	Species	Acronyms	R1	R2	R3	R4	R5	R6	R7	R8	S1	S2	S3	S4	P1	P2	N1	N2	N3	U
Dytiscidae	*Bidessus sharpi* Régimbart, 1895*	Bid.sh	+	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-
	Bidessus sodalis Guignot, 1939	Bid.so	-	-	-	-	-	-	+	-	-	-	-	-	-	+	-	+	-	-
	Cybister gschwendtneri Guignot, 1935	Cyb.gs	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-
	Hydroglyphus dakarensis (Régimbart, 1895)	Hydr.da	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-
	Hydrovatus aristidis Leprieur, 1879*	Hyv.ar	+	-	+	+	-	-	-	+	-	-	-	-	-	-	-	-	-	+
	Hydrovatus brevipilis Guignot, 1942*	Hyv.br	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Hydrovatus balneator Guignot, 1954	Hyv.pu	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-		
	Hydrovatus cribratus Sharp, 1882*	Hyv.cr	-	-	-	-	-	-	-	+	-	-	-	-	-	+	-	-	-	-
	Hydrovatus facetus Guignot, 1942*	Hyv.fr	-	+	-	+	-	-	-	-	-	-	-	-	-	+	-	-	-	-
	Hydrovatus parvulus Régimbart, 1900	Hyv.pa	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-
	Hydrovatus pictulus Sharp, 1882*	Hyv.ci	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-
	Hydrovatus regimbarti Zimmermann,1919	Hyv.sp	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-
	Hydrovatus suturalis Bilardo & Pederzani, 1978*	Hyv.sa	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-
	Hydrovatus villiersi Guignot, 1955*	Hyv.vi	-	-	-	+	-	+	+	-	-	-	-	-	-	+	-	-	-	-
	Hyphydrus impressus Klug, 1833*	Hyp.im	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Laccophilus occidentalis Biström *et al*., 2015*	Lac. oc	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-
	Laccophilus inobservatus Biström *et al*., 2015*	Lac.in	+	-	-	-	+	-	-	-	+	-	-	-	-	+	-	-	-	-
	Laccophilus? modestus Régimbart, 1895	Lac.mo	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-
	Laccophilus restrictus (Sharp, 1882)*	Lac.re	-	-	-	+	-	-	-	-	-	-	-	-	-	+	-	-	-	-
	Laccophilus sp. (cf. *restrictus* Sharp, 1882)	Lac.ver	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Laccophilus taeniolatus Régimbart, 1889 *	Lac.ta	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-
	Leiodytes sp.	Lei.sp	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-
	Methles sp.	Met.sp	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-
	Platydytes coarctaticollis (Régimbart, 1894)*	Plat.co	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	+	-	-
	Pseuduvarus vitticollis (Boheman, 1848)	Pse.vi	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-
	Yola cuspis Bilardo & Pederzani, 1979	Yol.cu	+	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-
	Yola nigrosignata Régimbart, 1895*	Yol.nig	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Noteridae	*Canthydrus imitator* Guignot, 1942*	Can.im	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Canthydrus koppi Wehncke, 1883*	Can.ko	+	+	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-
	Canthydrus xanthinus Régimbart, 1895	Can xa.	-	+	-	+	-	-	+	-	-	-	-	-	-	-	-	-	-	-
	Hydrocanthus colini Zimmermann, 1926	Can.col	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Hydrocanthus sp. (near *grandis*)	Can.sp	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-
	Synchortus simplex Sharp, 1882*	Syn.sp	-	-	+	+	-	-	-	+	-	-	-	-	-	+	-	-	-	-
	Synchortus sp. 1	Syn.sp1	-	-	-	+	-	-	+	-	-	-	-	-	-	-	-	-	-	-
	Synchortus sp. 2	Syn.sp2	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-
	Neohydrocoptus koppi Wehncke, 1883*	Neoh.ko	-	-	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Neohydrocoptus uellensis (Guignot, 1953)*	Neoh.sp1	-	-	-	+	-	-	-	+	-	-	-	-	-	-	-	-	-	-
	Neohydrocoptus sp.	Neoh.sp2	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-
Hydrophilidae	*Allocotocerus* sp.	All.sp	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-
	Amphiops sp. 1	Am.sp1	-	-	+	-	-	-	-	+	-	-	+	-	-	-	-	-	-	-
	Amphiops sp. 2	Am.sp2	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-
	Amphiops sp. 3	Am.sp3	-	-	-	-	+	-	+	-	-	-	-	-	-	-	-	-	-	+
	Amphiops sp. 4	Am.sp4	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-
	Amphiops sp. 5	Am.sp5	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Berosus sp.	Ber.sp	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-
	Coelostoma sp.	Coe. sp	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-
	Enochrus sp. 1	Eno.sp1	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Enochrus sp. 2	Eno.sp2	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-
	Enochrus sp. 3	Eno.sp3	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Helochares (*Hydrobaticus*) sp. 1	Hel.sp1	-	-	-	+	-	-	-	-	-	-	-	-	-	-	+	-	-	-
	Helochares (*Hydrobaticus*) sp. 2	Hel.sp2	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-
	Helochares (*Hydrobaticus*) sp. 3	Hel.sp3	+	-	-	-	-	+	+	+	+	-	+	-	-	-	+	-	-	+
	Helochares (*Hydrobaticus*) sp. 4	Hel.sp4	-	-	-	-	-	-	-	-	+	-	-	-	+	-	-	-	-	-
	Helochares (*Hydrobaticus*) sp. 5	Hel.sp5	-	-	-	+	-	-	-	-	-	-	-	-	+	-	-	-	-	-
	Helochares dilutus (Erichson, 1843)*	Hel.di	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-
	Helochares longipalpis (Murray, 1859)*	Hel.lo	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Helochares pallens MacLeay, 1825*	Helo.pa	+	-	+	-	-	-	-	+	-	-	-	-	-	+	-	-	-	-
	Helochares sp.	Hel.sp	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-
	Paracymus chalceus Régimbart, 1903*	Par.ch	+	-	-	-	-	-	-	-	-	-	-	-	+	+	-	-	-	-
	Regimbartia sp.	Reg.sp	-	-	-	-	-	-	-	+	-	-	-	-	-	+	+	-	-	-
Total number of species		**10**	**3**	**11**	**16**	**4**	**2**	**8**	**15**	**5**	**1**	**2**		**1**	**3**	**20**	**4**	**2**	**1**	**3**

Despite these restrictions, among the Hydrophilidae four species are newly recorded for Burkina Faso: *Helochares dilutus*, *H. longipalpis* , *H. pallens and Paracymus chalceus*. These four species are widely distributed in western, southern, eastern and central Africa (*Helochares longipalpis*, *H. pallens*, *Paracymus chalceus*). One species (*Helochares dilutus*) does not occur in northern Africa (Fikáček *et al*., 2012). Out of the 15 species of Dysticidae (*Bidessus sharpi, Hydrovatus aristidis, H. brevipilis, H. cribratus, H. cinctulus, H. villiersi, Laccophilus occidentalis, L. inobservatus, L. taeniolatus, L. restrictus Platydytes coarctaticollis*) newly recorded in Burkina Faso, seven species (*Hydrovatus aristidis,*

H. brevipilis, H. villiers, H. cribratus, Laccophilus restrictus, Yola nigrosignata, Platydytes coarctaticollis, Bidessus sharpi) are widely distributed in Sub-Saharan Africa (Nilsson *et al.*, 1995; Nilsson, 2001; Reintjes, 2004; Vondel, 2005; Bilardo and Rocchi, 2011, 2013; Nilsson, 2013) and two (*Laccophilus occidentalis, L. inobservatus*) are newly reported species (Biström *et al.*, 2015) . Based on our knowledge three species of Noteridae (*Canthydrus imitator*, *C. koppi* and *Synchortus simplex, Neohydrocoptus koppi, N. uellensis*) are widely distributed in West Africa, southern, Central and eastern Africa (Reintjes, 2004; Vondel, 2005; Guignot, 1959b; Medler, 1980; Bruneau and Legros, 1963; Legros, 1972; Bilardo and Pederzani, 1978; Nilsson, 2006) even though some of them are found in North Africa (Guignot, 1955a). The current knowledge of the water beetle fauna of Burkina Faso is limited and very scattered, a species list for the country is not available. In West Africa, especially in landlocked areas such as Burkina Faso, the species lists are still fragmentary and certainly far from being complete (Reintjes, 2004).

Table 4. correlation matrix of physico-chemical parameters and biological index marked with an asterisk (*) = statistically singnificant ($p<0.05$).

	W_Temp	pH	Cond	DO	W_Eich	W_Reed	W_Nymp	W_Pistia	B_Sed
W_Temperature	1								
pH	-0.449	1							
Conductivity	-0.021	0.227	1						
Dissolved Oxygen	-0.02	-0.01	-0.626*	1					
W_ *Eichhornia*	-0.31	-0.09	0.433	-0.43	1				
W_Reed	0.341	-0.5	-0.22	0.31	-0.286	1			
W_*Nymphea*	0.227	0.227	-0.09	0.182	-0.105	-0.419	1		
W_*Pistia*	-0.592*	0.591*	0.045	-0.05	-0.105	-0.419	-0.154	1	
B_Sediment	0.091	-0.02	0.045	-0.27	-0.105	-0.419	-0.154	-0.154	1
Hydrophilidae_taxa	0.103	0.363	0.366	-0.39	0.223	-0.175	-0.023	0.28	-0.16
Dytiscidae_ taxa	-0.262	0.015	-0.08	0.401	-0.127	0.317	-0.209	0.046	-0.21
Noteridae_ taxa	0.17	-0.34	-0.06	0.335	-0.265	0.744*	-0.388	-0.121	-0.39

This study revelead that several parameters determine the water beetles distribution. The vegetation cover and the type of water body are the most important. We provide evidence that the water body type and aquatic plants have much stronger influence on beetles species distribution than physico-chemical variables. The physico-chemical variables do not reveal the distribution of beetle species, but they showed the impact of human activies on water bodies. In this study, we found high conductuctivity and lower oxygen contents associated with the invasive *Eichhornia*. These values for the urban reservoir could be water pollution indicators in line with others works such as Benetti and Garrido (2010) and Pérez-Bilbao *et al*. (2014). The variation in species richness offers a good basis for the distinction between beetle communities in reservoirs with different types of aquatic plants ("Reeds", *Nymphea* and *Pistia*) and rivers. The Shannon Wiener diversity index and species richness were higher in reservoir sites than rivers. Our findings corroborate several previous ecological aquatic beetle studies which proved that water bodies and type of habitat were determinant variables for various beetle communities (Batzer and Wissinger, 1996; Reintjes, 2004; Gioria *et al.*, 2010; Epele and Archangelsky, 2012; Silva and Henry, 2013; Sanogo *et al.*, 2014). Despite that, the conductivity, pH values and dissolved oxygen values were quite variable among sites, they did not seem to affect water beetle

distributions. Such finding is in line with previous studies which pointed out that these variables had little or no influence on aquatic beetles (Arnott *et al.*, 2006; Pérez-Bilbao *et al.*, 2014). The vegetation cover is a key factor driving assemblage compositions, since many water beetles typical of lentic waters only need a few weeks to colonize temporary sites (Picazo *et al.*, 2012).

Fig. 1. Different types of habitats encountered in the investigation sites. a= water lilies “*Nymphea* sp.”, b =Reeds “Typha”, c= water lettuce “*Pistia stratiotes*”., d= Water hyacinth “*Eichhornia crassipes”*

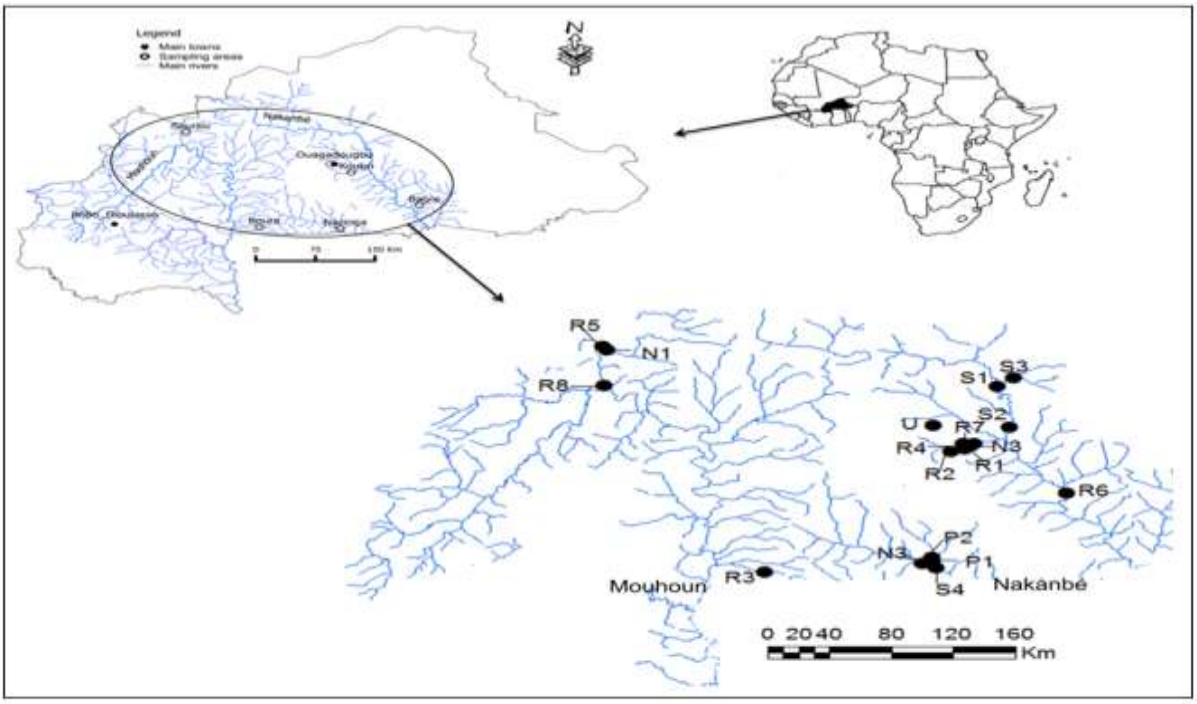

Fig. 2. Map of Burkina Faso in West Africa showing the location of sampling areas and sampled sites.

The previous study conducted by Reintjes (2004) showed that the rainfall was highly predictive of beetles taxa richness because they colonized aquatic plants during rainy season. In addition, insects are dependent on the litter deposited as vegetation dies and chemicals secreted by the plants, may also play a role in determining which plants support the greatest numbers and higher diversity of beetles (Fairchild *et al*., 2000; Menetrey *et al*., 2005). Gong *et al*. (2000), Albertoni *et al*. (2007), Silva and Henry (2013) and Koblinger and Trauner (2013) also demonstrated that the macrophytes enhance environmental heterogeneity, provide protection from predators and improve food condition for benthic macroinvertebrates.

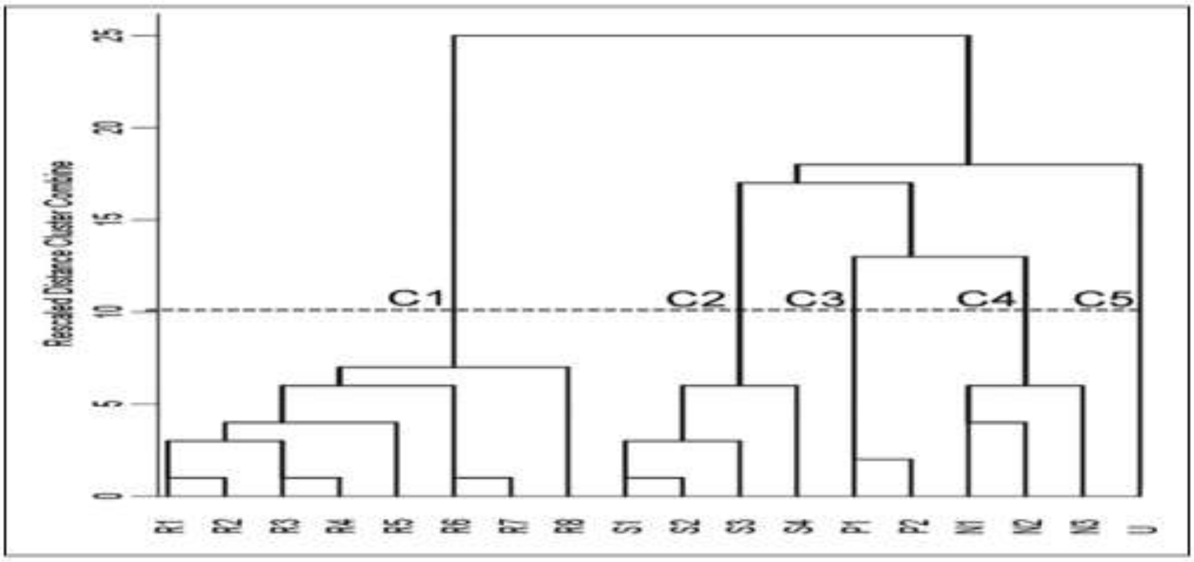

Fig. 3. Hierarchical classification of investigation sites related to their environment variables. Four main groups were shown by dendrogram, which C1=R1-R8 indicates "Reed Beds" sites ; C2=S1-S4 sites with sediment substrate, C3 (P1-P2)=reservoirs with *Pistia* cover, and C4 (N1-N3) mixed habitats with *Nymphea*, C5=Ouagadougou reservoirs with *Eichhornia*).

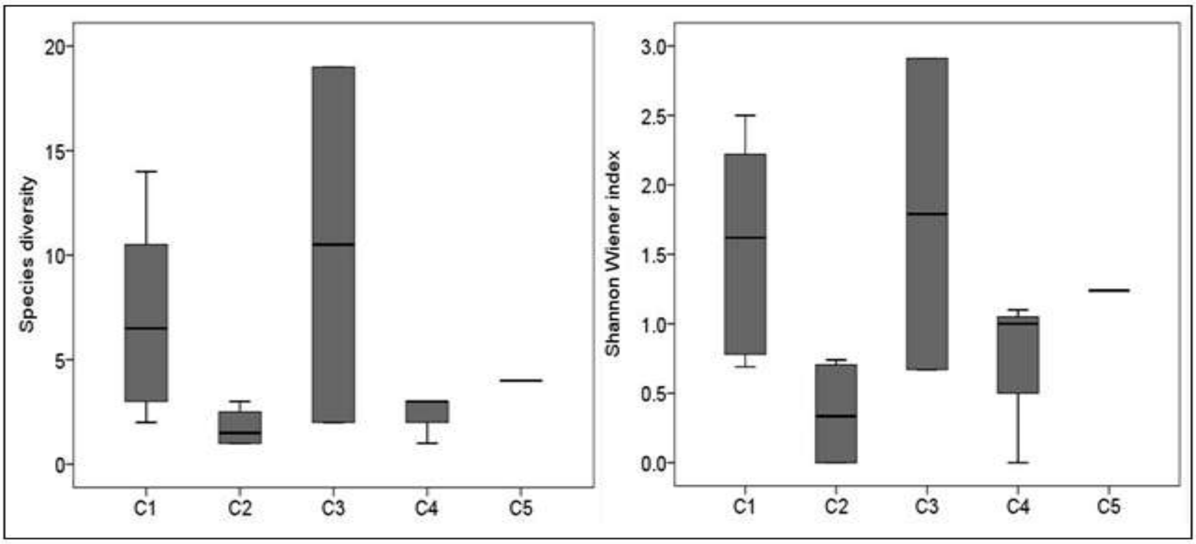

Fig. 4. Boxplot showing variation in species richness in diffrent waterbodies types. C1 indicates "Reed Beds" sites ; C2= sites with sediment substrate, C3=reservoirs with *Pistia* cover, and C4 mixed habitats with *Nymphea* and C5=Ouagadougou reservoirs with *Eichhornia*.

The negative association between *Nymphea* and beetles species was observed here. Taniguchi found in 2003 that the faunal differences in abundance and especially species richness between different water plants are related to leaf morphology and surface area of the plant that may have an important effect on a plant's ability to support beetles, which agrees with our results. This findings is also reflected in our results, as the structure-poor floating leaves (e.g. the anoxia in the centre of leaves) revealed by far the lowest faunal abundance and taxa richness of some sites. The water body type and vegetation cover are the most important variables in depicting the ecological health of beetles species in semi arid areas.

Conclusion

The knowledge of the water beetle fauna in West African landlocked countries is limited and very scattered. In this report 24 species are recorded from Burkina Faso for the first time, which is 40% of the total number, while thirty six (36) species were already listed by other authors. In West Africa the distribution of aquatic beetles are mostly influenced by the water body and aquatic plant habitats. Additionaly a significant direct and indirect impact of human pressures on waters was resulting in a loss of biodiversity. This first result proves the high beetle diversity in Burkina Faso and motivates for further efforts in monitoring, research as well as effective habitat conservation measures.

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